

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

0365-0501P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/831600

INTERNATIONAL APPLICATION NO.

PCT/FI99/00941

INTERNATIONAL FILING DATE

November 12, 1999

PRIORITY DATE CLAIMED

November 12, 1998

TITLE OF INVENTION

METHOD AND APPARATUS FOR DISCHARGING POLYMERIZATION REACTORS

APPLICANT(S) FOR DO/EO/US

KIVELA, Jouni; NYFORS, Klaus

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau). WO 00/29452
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☒ is transmitted herewith.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98-International Search Report (PCT/ISA/210) w/ 5 documents
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
 - 1.) PCT Request
 - 2.) International Preliminary Examination Report (PCT/IPEA/409)
 - 3.) Two (2) sheets of Formal Drawings

U.S. APPLICATION NO (if known, see 37 CFR 1.5) <div style="font-size: 2em; font-weight: bold;">09/831600</div>		INTERNATIONAL APPLICATION NO PCT/FI99/00941		ATTORNEY'S DOCKET NUMBER 0365-0501P	
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21. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):
 Neither international preliminary examination fee (37 CFR 1.482)
 nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
 and International Search Report not prepared by the EPO or JPO. **\$1,000.00**

International preliminary examination fee (37 CFR 1.482) not paid to
 USPTO but International Search Report prepared by the EPO or JPO **\$860.00**

International preliminary examination fee (37 CFR 1.482) not paid to USPTO
 but international search fee (37 CFR 1.445(a)(2)) paid to USPTO. **\$710.00**

International preliminary examination fee (37 CFR 1.482) paid to USPTO
 but all claims did not satisfy provisions of PCT Article 33(1)-(4) **\$690.00**

International preliminary examination fee (37 CFR 1.482) paid to USPTO
 and all claims satisfied provisions of PCT Article 33(1)-(4). **\$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =

Surcharge of **\$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30
 months from the earliest claimed priority date (37 CFR 1.492(e)).

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total Claims	34 - 20 =	14	X \$18.00
Independent Claims	3 - 3 =	0	X \$80.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable) Yes			+ \$270.00

TOTAL OF ABOVE CALCULATIONS =

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are
 reduced by 1/2.

SUBTOTAL =

Processing fee of **\$130.00** for furnishing the English translation later than ☐ 20 ☐ 30
 months from the earliest claimed priority date (37 CFR 1.492(f)).

TOTAL NATIONAL FEE =

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be
 accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **\$40.00** per property +

TOTAL FEES ENCLOSED =

CALCULATIONS	PTO USE ONLY
\$ 860.00	
\$ 0	
\$ 252.00	
\$ 0	
\$ 270.00	
\$ 1382.00	
\$ 0	
\$ 1382.00	
\$ 0	
\$ 1382.00	
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\$ 1422.00	
Amount to be: refunded \$	
charged \$	

a. ☒ A check in the amount of \$ **1422.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account. No. _____ in the amount of \$ _____ to cover the above fees.
 A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
 overpayment to Deposit Account No. 02-2448.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR
 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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Date: May 11, 2001

By #28977
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09/831600

PATENT

0365-0501P

JC18 Rec'd PCT/PTO 11 MAY 2001

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: KIVELA, Jouni et al. Conf.:
Int'l. Appl. No.: PCT/FI99/00941
Appl. No.: New Group:
Filed: May 11, 2001 Examiner:
For: METHOD AND APPARATUS FOR DISCHARGING
POLYMERIZATION REACTORS

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION

Assistant Commissioner for Patents
Washington, DC 20231

May 11, 2001

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/FI99/00941 which has an International filing date of November 12, 1999, which designated the United States of America and was published in English.--

IN THE CLAIMS:

Please amend the claims as follows:

6. (Amended) The method according to claim 2, wherein the control valve is adjusted to provide for pulsating operation to prevent clogging of the valve.

7. (Amended) The method according to claim 1, wherein polymer powder is continuously withdrawn from a point above a fluidization plate.

8. (Amended) The method according to claim 1, wherein polymer powder is continuously withdrawn from a point below the bed level.

9. (Amended) The method according to claim 1, wherein the discharge line and the control valve are discontinuously backflushed with a flushing gas flow.

10. (Amended) The method according to claim 1, comprising

- using a gas phase reactor having a mechanically mixed zone of the fluidized bed, and
- continuously withdrawing polymer powder from said mixed zone.

11. (Amended) The method according to claim 1, wherein polymer powder is also separately withdrawn from the reactor using a discontinuous discharge device.

12. (Amended) The method according to claim 1, wherein the polymer powder is withdrawn together with gas from the reactor, the gas is separated from the polymer powder, and the separated gas is recycled into the reactor.

13. (Amended) The method according to claim 1, wherein polymer agglomerates are withdrawn from the reactor using a discharge line with a discontinuously operated discharge valve.

19. (Amended) The method according to claim 1, wherein the catalyst is fed into the gas phase reactor as a stream comprising polymer and active catalyst together with reaction medium.

22. (Amended) The method according to claim 1, wherein the monomers are selected from the group of C₂ to C₁₆ olefins and mixtures thereof.

23. (Amended) The method according to claim 1, wherein the monomer is selected from the group of ethylene, propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, dienes, and cyclic olefins, and mixtures thereof.

24. (Amended) The method according to claim 1, wherein the polymer that is continuously withdrawn is either directly or indirectly fed into another gas phase reactor.

25. (Amended) The method according to claim 14, wherein the collecting vessel is connected to a gas separator, said polymer powder being pneumatically conducted from the collecting vessel to the gas separator.

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application. The claims have also been amended to delete improper multiple dependencies and to place the application into better form for examination. Entry of the present amendment and favorable action on the above-identified application are earnestly solicited.

Attached hereto is a marked-up copy of the changes made to the application by this Amendment.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

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ADM/cqc
0365-0501P

Attachment: Version With Markings Showing Changes Made

(Rev. 01/22/01)

VERSION WITH MARKINGS SHOWING CHANGES MADE

The specification has been amended to provide cross-referencing to the International Application.

The claims have been amended as follows:

6. (Amended) The method according to [any of claims 2 to 5]claim 2, wherein the control valve is adjusted to provide for pulsating operation to prevent clogging of the valve.

7. (Amended) The method according to [any of the preceding claims]claim 1, wherein polymer powder is continuously withdrawn from a point above a fluidization plate.

8. (Amended) The method according to [any of the preceding claims]claim 1, wherein polymer powder is continuously withdrawn from a point below the bed level.

9. (Amended) The method according to [any of the preceding claims]claim 11, wherein the discharge line and the control valve are discontinuously backflushed with a flushing gas flow.

10. (Amended) The method according to [any of the preceding claims]claim 1, comprising

- using a gas phase reactor having a mechanically mixed zone of the fluidized bed, and
- continuously withdrawing polymer powder from said mixed zone.

11. (Amended) The method according to [any of the preceding claims]claim 1, wherein polymer powder is also separately withdrawn from the reactor using a discontinuous discharge device.

12. (Amended) The method according to [any of the preceding claims]claim 1, wherein the polymer powder is withdrawn together with gas from the reactor, the gas is separated from the polymer powder, and the separated gas is recycled into the reactor.

13. (Amended) The method according to [any of the preceding claims]claim 1, wherein polymer agglomerates are withdrawn from the reactor using a discharge line with a discontinuously operated discharge valve.

19. (Amended) The method according to [any of the preceding claims]claim 1, wherein the catalyst is fed into the gas phase reactor as a stream comprising polymer and active catalyst together with reaction medium.

22. (Amended) The method according to [any of the preceding claims]claim 1, wherein the monomers are selected from the group of C₂ to C₁₆ olefins and mixtures thereof.

23. (Amended) The method according to [any of the preceding claims]claim 1, wherein the monomer is selected from the group of ethylene, propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, dienes, and cyclic olefins, and mixtures thereof.

24. (Amended) The method according to [any of the preceding claims]claim 1, wherein the polymer that is continuously withdrawn is either directly or indirectly fed into another gas phase reactor.

25. (Amended) The method according to [any of claims 14 to 24]claim 14, wherein the collecting vessel is connected to a gas separator, said polymer powder being pneumatically conducted from the collecting vessel to the gas separator.

**METHOD AND APPARATUS FOR DISCHARGING POLYMERIZATION
REACTORS****Background of the Invention****Field of the Invention**

The present invention relates to a method of producing polymers in a continuously operated polymerization reactor. In particular, the invention concerns a method of continuously withdrawing solid polymer powder from a fluidized bed polymerization reactor with high throughput. The present invention also concerns an apparatus for continuous withdrawal of polymer powder from a fluidized bed polymerization reactor.

Description of Related Art

A number of processes for preparing polymers in a fluidized bed reactor are known in the art. Such processes are described in e.g. EP Patent Specification No. 0 517 868, U.S. Pat. No. 4 543 399 and EP Patent Application No. 0 381 364. The processes are primarily designed for the production of polyethylene but they can also be modified for preparing other polyolefins, such as polypropylene. In the process described in EP Patent Specification No. 0 517 868 the fluidized bed reactor acts as a second reactor in a two-reactor train, in the other above-mentioned processes it is a stand-alone reactor.

Conventional gas phase fluidized bed reactors comprise an elongated reactor body generally having a vertical central axis. The monomers are polymerized in a fluidized bed above a fluidization grid located in the bottom end of the reactor body. A gaseous stream containing monomer, and optionally alpha-olefin comonomer(s), hydrogen and inert gas(es) is introduced to the bottom of the bed through the fluidization grid. The unreacted gas is collected from the top of the bed, cooled and recycled to the bottom of the reactor. The polymer product is withdrawn from the lower part of the reactor above the fluidization grid. Active catalyst is introduced into the bed, either as a fresh catalyst or as polymer particles from a prior polymerization stage, wherein the active catalyst is dispersed.

The polymerization system of a gas phase reactor used for polymerization of α -olefins comprises a fluidized bed consisting of polymer particles containing the active catalyst within, and a gaseous reaction medium. The bed can be maintained in the fluidized state by

mechanically mixing or stirring the contents of the reactor and additionally or alternatively by blowing the monomer(s), i.e. the olefin(s), and/or an inert reaction medium (e.g. nitrogen and/or an easily volatile hydrocarbon) into it in a gaseous state. In the case of a fluidized bed process, the velocity of the gas needs to be sufficient to support or fluidize the polymer particles. The monomer(s) and/or an inert reaction medium in liquid state can be introduced into the polymerization system and the polymerization can be carried out while gasifying said monomer(s) and/or reaction medium. The unreacted monomer(s) and/or inert reaction medium can be partly or wholly liquefied and recycled in liquid state into the polymerization system, as disclosed in EP-A1 0 024 933.

As disclosed in a US Patent No. 4,803,251, sheet formation is occasionally encountered in gas phase reactors. The sheets are particle agglomerates having a thickness of about 6 to 15 mm, length of about 30 to 150 cm and width of 7.5 to 45 cm or more. The sheets consist of fused polymer. According to US 4,803,251, the formation of sheets is associated with static electricity. The possible formation of hot spots, which eventually may lead to chunk formation as disclosed in EP 0 089 691, was also discussed.

Conventionally, the withdrawal of the polymer product from a gas phase reactor is carried out batch-wise. A typical batch discharge process consists of the following steps: When the surface level within the gas phase reactor rises as a result of polymerization, polymer powder is discharged through an on/off valve to an outlet tank. A part of the fluidizing gas entering the tank with powder is recycled by a compressor back to the fluidized bed. The degassed powder is recovered and optionally subjected to further processing.

By means of the batch-wise discharge system described above it is possible to remove not only the polymer powder but also lumps formed in the reactor, because the outlet nozzles of the system have a large diameter, generally much larger than required by the withdrawal of the powder.

There are, however, some serious disadvantages associated with conventional technology. The batchwise discharge is a rather complicated system. It comprises several phases and a number of on/off valves, which typically operate tens of times an hour. There has to be at least two discharge systems, in large plants even more. This feature makes the batch-wise discharge system rather expensive as an investment and also the maintenance is cost-consuming. The complexity of the system also makes it vulnerable; if the discharge system becomes clogged or there is a serious failure in the system, the whole plant has to be shut

down.

Further, the batch-wise discharge is inflexible because it is difficult to increase its capacity when the capacity of the whole plant is increased. Instead, a major rise in the production capacity requires the addition of a new expensive discharge system.

As regards the operation of the system, it can be noted that there is a distinct fluctuation in the bed level when a batch of the polymer product is withdrawn from the reactor. This fluctuation influences the monomer concentration and, thus, also other parameters, such as the concentration of hydrogen and comonomers, which all taken together have a strong impact on the the quality of the polymer product.

The discontinuous operation of the outlet system also leads to a pulsating operation of the recycle gas compressor. This, again, leads to increased wear.

Some alternative systems for withdrawal of polymer powder from a fluidized bed reactor are also described in the art. Such processes are described in EP Published Patent Applications Nos. 0 006 288 and 0 245 043 and US Patent No. 4 495 337.

The last-mentioned document discloses a process for bottom drainage of a fluid-bed reactor, in which the reactor is provided not only with a vertical bottom pipe but also with a lateral evacuation pipe located above the distribution plate of the reactor. The side pipe makes it possible to evacuate a part of the polymer formed in the reactor. According to the reference, to empty the reactor, first all the fraction of polymer powder located above the level of the outlet pipe is discharged by means of the lateral pipe, then total drainage of the reactor is carried out via the vertical bottom pipe.

EP A1 0 006 288 and A1 0 245 043 disclose discharge systems which are discontinuously or continuously operated. In EP A1 0 006 288 the discharge is effected via a dipleg, which passes from the top of the reactor to a point near the bottom. The dip leg is connected to an on/off valve, which is opened intermittently. When the valve is open, a mixture of polymer and monomer is passed on to a cyclone in which most of the monomer vapour is separated from the polymer. The monomer can be recycled to the reactor via compressor.

EP A1 0 245 043 teaches an apparatus for degassing and pelleting polyolefins, in which there is an outlet nozzle which is equipped with a lock chamber placed between two valves

activated alternately. The mixture of gas and solid particles, withdrawn from the reactor, is treated in a primary degasser for separating the solid phase from a part of the gas phase accompanying the particles. The gases containing monomers are recycled into the reactor by a pipe.

Although the prior art suggests that the above three alternative discharge systems can be not only periodically operated but also continuously, none of them is in fact adapted for such operation. It should be noted that the control valves described in EP A1 0 006 288 and A1 0 245 043 are actually intermittently operated which means that there is no continuous stream of polymer powder through the outlet nozzles. Thus, these systems are merely improved batch discharge systems, which have the same main disadvantages as described above. The discharge system of US 4 495 337 is, on the other hand, suitable for draining of the whole content of the reactor rather than for allowing for continuous withdrawal of polymer powder.

JP-A-58/113208 discloses a process for continuously polymerizing olefins in vapour phase. The level of the fluidized bed is determined by measuring the pressure difference between two specified locations in the bed. The document further indicates that the polymer can be withdrawn either continuously or intermittently. How the suggested continuous withdrawal is made in practice is not disclosed.

EP-A-0 870 539 discloses an apparatus for polymerizing olefins in gas phase. Figure 2 and column 8, lines 21-55 of the document describe an embodiment, wherein the polymer is withdrawn continuously from the reactor. The document does not refer to the presence of any chunks or sheets among the polymer, and does not suggest how these should be handled when withdrawing polymer from the reactor. It merely discusses how the gas discharge pipe should be installed to prevent it from blocking.

Summary of the Invention

It is an object of the present invention to eliminate the problems related to the prior art of polymer powder discharge systems and to provide a simple discharge method with high throughput, which is capable of stabilizing fluidized bed polymerization reactor control and downstream equipment operation.

Another object of the present invention is to provide a discharge system with low

investment cost and substantially reduced maintenance cost.

These and other objectives, together with the advantages thereof over known processes, which shall become apparent from the following specification, are accomplished by the invention as hereinafter described and claimed.

The present invention is based on the concept of polymerizing at least one monomer in a gas phase reactor by continuously feeding a monomer into a bed formed by catalyst polymer particles suspended in a fluid and defining a bed level in the reactor. According to the invention free-flowing polymer powder is continuously with-drawn through a discharge pipe, while simultaneously monitoring the surface level of the fluidized bed within a gas phase reactor, and controlling the flow of material through the pipe depending on the surface level so as to maintain an essentially constant bed level. To achieve this aim, the gas phase reactor is provided with an outlet nozzle which is equipped with a continuously operated control valve for the powder discharge. The control signal for the control valve comes from a fluidized bed level controller. The bed level is typically measured with a pressure difference or radio-active device.

Further, the present invention comprises withdrawing and separately (continuously or discontinuously) recovering particle agglomerates from the reactor.

The discharge system comprises an outlet nozzle, a control valve and a bed level indicator. Preferably the system further comprises a collecting vessel placed in communication with the outlet pipe for separating gas from solid material. The particle agglomerates are either withdrawn directly from the reaction via a separate outlet or the agglomerates are separated from the continuous flow of polymer powder.

More specifically, the method according to the present invention is characterized by what is stated in the characterizing part of claim 1.

The apparatus according to the present invention is characterized by what is stated in the characterizing part of claim 26.

The present invention provides considerable advantages. Thus, the discharge of the polymer can be made truly continuous without any disturbance of the polymerization. The rate of withdrawn polymer can be flexibly adjusted depending on the progress of the

polymerization and it can also easily be scaled up if the capacity of the reactor is increased. Further, it has been observed that a mixture of gas and polymer can pass through the continuously operating control valve. Such a mixture can be used for pneumatically conveying polymer powder. Also, it has been observed that less reaction gas is discharged than with batchwise systems.

Particularly well the continuous outlet system is suited to a process where the outlet from the gas phase reactor is either directly or indirectly fed into another gas phase reactor. This avoids the control upsets in the next gas phase reactor due to the sequential powder feed.

Generally, it has not been deemed possible to achieve continuous discharge because in particular in a PE reactor there are formed considerable amounts of lumps and clogs and the size of a continuously operating outlet nozzle is so small that such lumps will eventually cause clogging thereof. By the present invention it is possible to avoid said problem.

Next, the invention will be examined more closely with reference to the attached drawings and a detailed description.

Brief Description of the Drawings

Figure 1 shows in a schematical fashion a first embodiment of the invention comprising a fluidized bed reactor with an outlet nozzle, a pipe, a continuously operated control valve provided with means for flushing of the valve, and a processing section for separating gas containing unreacted monomers from the polymer powder; and

Figure 2 depicts in a schematical fashion a second embodiment of the present invention comprising a fluidized bed reactor with an outlet nozzle, a collecting vessel, a control valve operated under the control of a level indicator, and a processing section for separating gas containing unreacted monomers from the polymer powder.

Detailed Description of the Invention

According to the invention, the present method is used for discharging polymer from a continuously operated gas phase reactor, wherein at least one monomer is polymerized in a bed containing catalyst and polymer particles suspended in a fluid, said bed defining a fluidized bed level in said reactor. The catalyst can be fed into the gas phase reactor as a

stream comprising polymer and active catalyst together with reaction medium. Such a stream can be obtained from a slurry reactor, such as a loop reactor.

The method comprises continuously withdrawing polymer powder from the reactor and adjusting the discharge rate of the polymer powder so as to maintain a constant bed level during polymerization. As mentioned above, the discharge rate of the polymer powder is adjusted by using a continuously operated control valve. Preferred examples of such continuously operated valves are ball valves, V-ball valves and hose valves.

To ensure stable operation of the process, the polymer powder should be free-flowing. The flow properties of the polymer produced in the process depend on the average particle size, particle size distribution and especially shape of the polymer particles. These properties further depend on the corresponding properties of the catalyst used in the process. To achieve good flow properties, the polymer particles should have an average particle size between 150 and 4,000 microns, preferably between 200 and 2,000 microns. The particle size distribution should be such that no more than 30 %, preferably no more than 15 % by weight of the particles should have a diameter smaller than 100 microns. Moreover, the polymer particles should have a smooth surface and a regular appearance. Preferably the particles should have a spherical or near spherical shape.

Together with or separately from the free-flowing polymer powder, polymer agglomerates are also withdrawn from the reactor and recovered. They may be discarded or milled and mixed with the ready polymer. Polymer "particle agglomerates" are particles having a minimum thickness (in any dimension) of at least about 6 mm, in particular about 6 to 15 mm. They consist of polymer particles which are at least partially fused together. The agglomerates comprise sheets, chunks and lumps formed during polymerization, in particular in the gas phase reactor. As mentioned above, polymer agglomerates will be formed in particular during polymerization of ethylene.

The apparatus comprises an outlet nozzle communicating with the fluidized bed of the gas phase reactor, a collecting vessel placed in communication with the outlet nozzle for separating gas from solid material; a continuously operating valve for adjusting the amount of polymer powder withdrawn from the reactor via the outlet nozzle; and means for controlling the operation of the valve for adjusting the discharge rate of the polymer powder so as to maintain a constant bed level during polymerization. The continuously operating valve is preferably connected to the collecting vessel. Polymer agglomerates may

be withdrawn from the reactor using a discharge line with a discontinuously operated discharge valve. Alternatively, polymer agglomerates are separated from the polymer powder in a collecting vessel provided with a screen for isolating the lumps, sheets or clogs.

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A first preferred embodiment of the invention is shown in Figure 1. In the drawing, the following reference numerals are used:

- | | | |
|----|-----|---|
| 10 | 1. | gas phase reactor |
| | 2. | outlet nozzle of gas phase reactor |
| | 3. | control valve |
| | 4. | level indicator/controller |
| | 5. | discharge line |
| 15 | 7. | collecting vessel |
| | 8. | flush gas |
| | 12. | valve regulating the flow of polymer powder |
| | 18 | product receiver or second reactor |
| | 20 | gas surge drum |
| 20 | 21 | compressor |

As shown in the drawing, polymer formed in the reactor 1 is withdrawn from a point below the bed level, via an outlet nozzle 2 and a control valve 3 together with a sufficient amount of gas for conducting the polymer to a degassing vessel 18 or to a subsequent reactor. The operation of the control valve 3 is controlled by the level indicator/controlling means 4. The gas separated from the polymer powder in the degassing section is recycled after the separation of the polymer to the gas phase reactor, as indicated by the arrow, and/or to a recovery section.

30 The continuous withdrawal is preferably used as a single discharge system in case of a reactor wherein the amount of lumps is small. The formation of lumps can be reduced by adding various antistatic agents or by avoiding feeding fresh catalyst to the gas phase reactor, as in a multistep process. A particularly preferred multi-step process is represented by the system disclosed in EP Patent Specification No. 0 517 868, which comprises in
35 combination a loop reactor and a gas phase reactor.

Even in this embodiment, it is advantageous to place the outlet nozzle 2 at a point where no or practically no lumps are present. To that aim the polymer powder can be continuously withdrawn from a point above a fluidization plate, since the lumps tend to accumulate on
40 the fluidization plate. When a gas phase reactor is used, wherein the fluidized bed

comprises a mechanically mixed bed, the polymer powder is preferably withdrawn from said mixed zone.

In order to reduce the risk of clogging of the discharge system, the outlet nozzle can be provided with a grid (not shown) flush mounted at the reactor wall to prevent lumps from entering the pipe. The term "flush mounted" means that the grid is installed so that it is at the same level as the surface of the inner wall of the reactor. It must not extend from the wall surface to the reactor, otherwise it would be covered with polymer. Also, it must not leave a pocket at the nozzle which would allow accumulation of polymer there. Further, the discharge line 5 and the control valve 3 can be discontinuously backflushed with a flushing gas flow through gas conduit 8 to prevent clogging. Similarly, the control valve 3 can be adjusted to provide for pulsating operation to prevent clogging of the valve by a control means 4. Preferably, this is done by opening the valve fully for a short time and then turning it back to its normal position. This procedure is automatically repeated with specified intervals.

Since it is normally not possible to avoid lump-forming totally, though it can be reduced to a minimum, as discussed above, it is preferred to combine the present continuous discharge system with a conventional batchwise system, as shown in Figure 1. In the present embodiment the batch-wise discharge system is represented by a collecting tank 7, which is connected to the gas phase reactor via a gas conduit. By batch-wise withdrawal it is possible to prevent accumulation of lumps on the distribution plate of the gas phase reactor 1. In a process according to the present invention, the batchwise operated system can be designed for a substantially smaller capacity than conventionally and it can be operated less frequently, for example only once an hour or even only once a day. Generally one batchwise outlet nozzle should be enough for withdrawal of lumps (polymer aggregates). The lumps can be detected by radioactive detection sensors.

Typically, if the reactor is provided with a discontinuous polymer discharge system, the ratio between the polymer powder continuously discharged from the reactor to polymer powder discharge via the batchwise operated system is about 1:1 to 10,000:1.

The degassing of the polymer powder takes place in at least one degassing vessel, wherein the pressure of the gas flow is decreased to remove the gas from powder. The degassing section 18, 20 can comprise a product receiver 18 for separating gas from the polymer powder and a gas surge drum 20. The polymer powder is pneumatically conducted from the

collecting vessel 7 to the product receiver 18 or a second reactor.

The pressure of the gas from the gas collecting vessel can be increased in a compressor 21 before the gas is recycled to a gas phase reactor, directly or through a recovery system/section.

Figure 2 shows another preferred embodiment for continuous withdrawal. The parts of the equipment are largely the same as in the previous embodiment, viz.:

- | | | |
|----|--------|--|
| 10 | 31. | gas phase reactor |
| | 32. | outlet nozzle of gas phase reactor |
| | 33. | control valve for gas |
| | 34. | level indicator/controller |
| | 35. | collecting tank |
| 15 | 36. | recycle line |
| | 37. | screen |
| | 38. | outlet nozzle to remove lumps from collecting tank |
| | 39. | level indicator/controller |
| | 40. | control valve to regulate the flow of powder |
| 20 | 41. | On-off valve for removal of lumps |
| | 43, 45 | collecting tanks of degassing section |
| | 46 | compressor |

In the embodiment shown in Figure 2, the outlet nozzle 32 of the gas phase reactor 31 is combined with a separate collecting vessel 35, which can be used for separating lumps from the fluid comprising polymer powder and gas. The bed level of the gas phase reactor 31 is controlled by a recycle valve (control valve) 33 fitted in the recycle line 36 connected to the the gas space of the collecting vessel. Gas is recycled to the upper part of the reactor above the fluidized bed and the bed height gives the necessary pressure difference for conducting the polymer and the gas to the collecting vessel 35.

The collecting vessel 35 is preferably provided with a separate level controller 39 and a control valve 40 and polymer is pneumatically conducted under the influence of the pressure of the collecting vessel 35 to a degassing vessel 43 or to a subsequent reactor. It is preferred to provide the collecting vessel with a screen 37 for collecting the lumps and with a separate discharge nozzle 38 for the lumps. The control valve 40 may be operated either intermittently or continuously. It is preferred to operate the valve 40 continuously.

The operation of the degassing section 43 - 46 is similar to that of the first embodiment explained above.

The polymer continuously withdrawn can be directly or indirectly fed into another gas phase reactor.

The present invention can be used for producing homo- and copolymers from monomers selected from the group of C_2 to C_{16} olefins and mixtures thereof. Preferably the monomer is ethylene, propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, a diene, or cyclic olefin, or a mixtures thereof.

The following non-limiting Examples illustrate the invention.

Comparative example:

A production scale gas phase reactor was operated at 85 °C temperature and 20 bar pressure with a bed level of 15 m as follows:

Polymer containing active polymerization catalyst was fed into the gas phase reactor from a loop reactor at a rate of 6 metric tons per hour. The feed rates of ethylene, hydrogen and 1-butene were adjusted so that desired concentrations in the gas phase reactor were reached. As a consequence, the polymer production rate in the gas phase reactor was 8 tons per hour and the polymer taken out of the reactor had an $MFR_{21} = 11$ and density = 947 kg/m³.

The polymer was collected from the reactor using a conventional, batchwise product outtake system, where the polymer was collected into a 3.7 m³ receiving tank. Two identical systems were used. The diameter of the outtake nozzle was 8 inches. The period between two successive outtakes was two minutes, i.e. four minutes for each individual system. During a normal operation the bed level was found to oscillate with a 20 cm amplitude. The reactor could be operated several days without a shut-down.

An experiment to operate the product outtake with its maximum capacity was made, and then the capacity was found to be 20 tons per hour.

Example:

A product outtake system according to the present invention was installed in the gas phase reactor of the Comparative example. The diameter of the nozzle was 2 inches (50 mm). Every minute the control valve was fully opened for a few seconds to prevent clogging of

the valve. The conventional discontinuous outtake was set to operate once an hour to remove any lumps from the reactor. No lumps were actually collected from the reactor during the test period and it was thus concluded that the operation frequency of the discontinuous outlet could have been even lower.

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The conditions of the reactor were similar to the Comparative example. During the normal operation the bed level was found to oscillate with a 5 cm amplitude. The reactor was operated several days in a stable fashion until the test was interrupted.

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In an experiment according to the Comparative example the maximum capacity of the outtake was found to be 45 tons per hour.

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In the Claims

1. A method of producing a polymer in a continuously operated gas phase reactor, comprising

- polymerizing at least one monomer in a bed containing active catalyst formed by catalyst and polymer particles suspended in a fluid, said bed defining a fluidized bed level in said reactor,
- continuously withdrawing polymer powder from the reactor;
- adjusting the discharge rate of the polymer powder so as to maintain a constant bed level during polymerization; and
- withdrawing and separately recovering particle agglomerates from the reactor.

2. The method according to claim 1, wherein the discharge rate of the polymer powder is adjusted by using a continuously operated control valve.

3. The method according to claim 2, wherein the continuously operated valve is a ball valve, a V-ball valve or a hose valve.

4. The method according to claim 2 or 3, wherein the polymer powder is withdrawn via an outlet nozzle connected to the control valve, and said nozzle is provided with a grid flush mounted at the reactor wall to prevent lumps from entering the pipe.

5. The method according to any of claims 2 to 3, wherein the operation of the control valve is adjusted by using a control signal obtained from a bed level controller.

6. The method according to any of claims 2 to 5, wherein the control valve is adjusted to provide for pulsating operation to prevent clogging of the valve.

7. The method according to any of the preceding claims, wherein polymer powder is continuously withdrawn from a point above a fluidization plate.

8. The method according to any of the preceding claims, wherein polymer powder is continuously withdrawn from a point below the bed level.

9. The method according to any of the preceding claims, wherein the discharge line and the control valve are discontinuously backflushed with a flushing gas flow.

10. The method according to any of the preceding claims, comprising
- using a gas phase reactor having a mechanically mixed zone of the fluidized bed, and
 - continuously withdrawing polymer powder from said mixed zone.

11 The method according to any of the preceding claims, wherein polymer powder is also separately withdrawn from the reactor using a discontinuous discharge device.

12. The method according to any of the preceding claims, wherein the polymer powder is withdrawn together with gas from the reactor, the gas is separated from the polymer powder, and the separated gas is recycled into the reactor.

13. The method according to any of the preceding claims, wherein polymer agglomerates are withdrawn from the reactor using a discharge line with a discontinuously operated discharge valve.

14. A method of discharging polymer from a continuously operated gas phase reactor, wherein at least one monomer is polymerized in a bed containing active catalyst formed by catalyst and polymer particles suspended in a fluid, said bed defining a fluidized bed level in said reactor, comprising

- continuously withdrawing polymer powder from the reactor;
- feeding the withdrawn polymer powder into a collecting vessel, wherein lumps are separated from finely-divided polymer powder and at least a part of the gas is separated from the solid material;
- recovering the lumps, and
- adjusting the discharge rate of the polymer powder so as to maintain a constant bed level during polymerization.

15. The method according to claim 14, wherein the separated gas is recycled into the reactor, said collecting vessel being provided with a return valve for adjusting the gas flow recycled to the reactor.

16. The method according to claim 15, wherein the return valve is controlled by the fluidized bed level of the reactor.

17. The method according to claim 16, wherein the polymer level in the vessel is

controlled by using a continuously operating control valve.

18. The method according to any of claims 14 to 17, wherein the collecting vessel is provided with a screen for separating lumps.

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19. The method according to any of the preceding claims, wherein the catalyst is fed into the gas phase reactor as a stream comprising polymer and active catalyst together with reaction medium.

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20. The method according to claim 19, wherein the catalyst is fed into the gas phase reactor from a slurry reactor.

21. The method according to claim 20, wherein the slurry reactor is a loop reactor.

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22. The method according to any of the preceding claims, wherein the monomers are selected from the group of C₂ to C₁₆ olefins and mixtures thereof.

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23. The method according to any of the preceding claims, wherein the monomer is selected from the group of ethylene, propylene, 1-butene, 4-methyl-1-pentene, 1-hexene, dienes, and cyclic olefins, and mixtures thereof.

24. The method according to any of the preceding claims, wherein the polymer that is continuously withdrawn is either directly or indirectly fed into another gas phase reactor.

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25. The method according to any of claims 14 to 24, wherein the collecting vessel is connected to a gas separator, said polymer powder being pneumatically conducted from the collecting vessel to the gas separator.

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26. An apparatus for discharging polymer from a continuously operated gas phase reactor, wherein at least one monomer is polymerized in a bed containing active catalyst formed by catalyst and polymer particles suspended in a fluid, said bed defining a fluidized bed level in said reactor, said apparatus comprising

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- an outlet nozzle communicating with the fluidized bed of the gas phase reactor,
- a collecting vessel placed in communication with the outlet nozzle for separating gas from solid material, with a screen for collecting the lumps and a separate discharge nozzle for the lumps;

- a continuously operating valve for adjusting the amount of polymer powder withdrawn from the reactor via the outlet nozzle; and
- means for controlling the operation of the valve for adjusting the discharge rate of the polymer powder so as to maintain a constant bed level during polymerization.

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27. The apparatus according to claim 26, wherein the continuously operating valve is connected to the collecting vessel.

28. The apparatus according to claim 26 or 27, wherein the collecting vessel comprises a gas space which is connected to the gas phase reactor via a gas conduit.

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Abstract

A method and an apparatus of discharging polymer from a continuously operated gas phase reactor, wherein at least one monomer is polymerized in a bed containing active catalyst
5 formed by catalyst and polymer particles suspended in a fluid, the bed defining a fluidized bed level in said reactor. The invention comprises continuously withdrawing polymer powder from the reactor; and adjusting the discharge rate of the polymer powder so as to maintain a constant bed level during polymerization. By means of the invention the
10 discharge of the polymer can be made truly continuous without any disturbance of the polymerization. The rate of withdrawn polymer can be flexibly adjusted depending on the progress of the polymerization and it can also easily be scaled up if the capacity of the reactor is increased.

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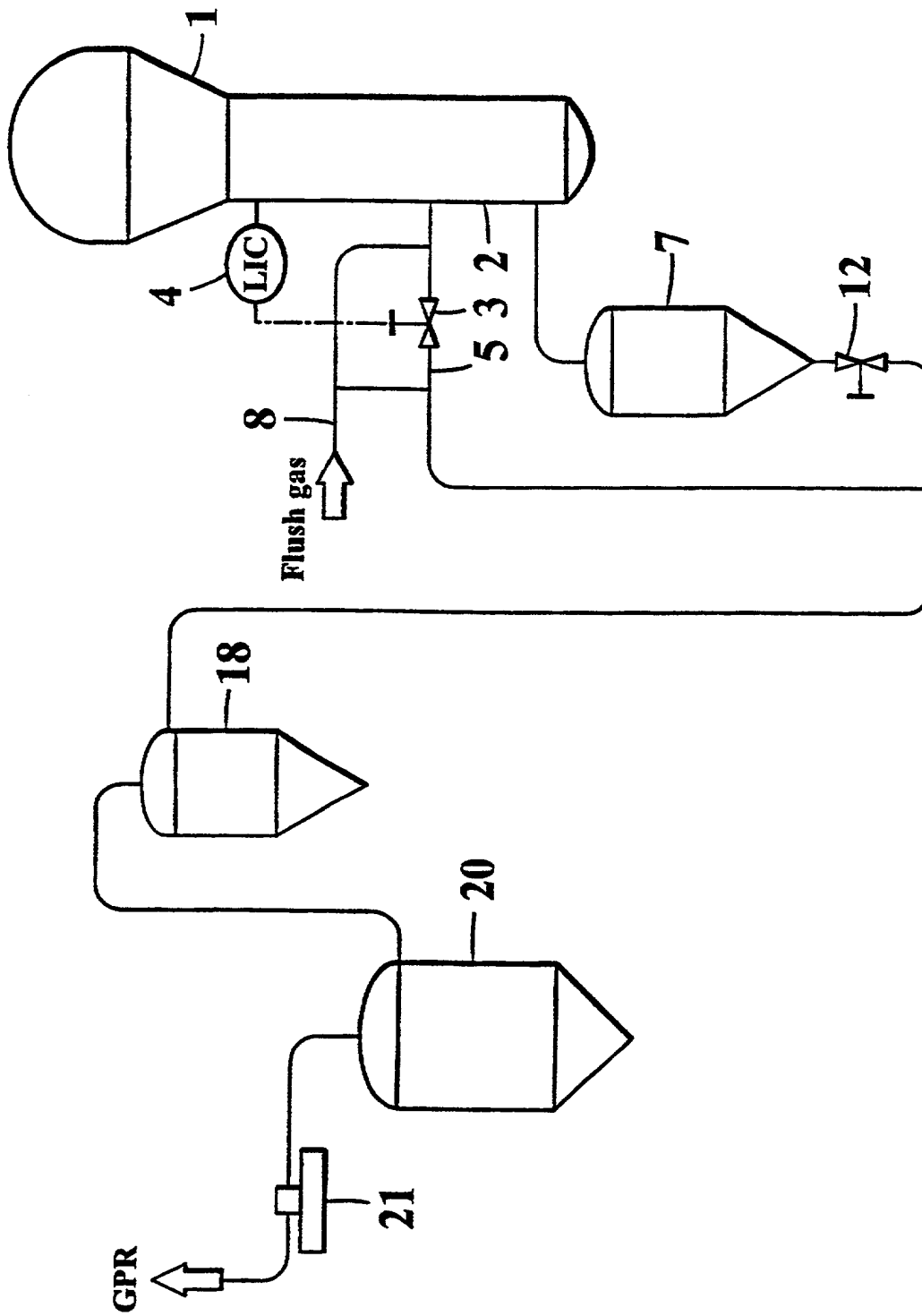


FIG. 1

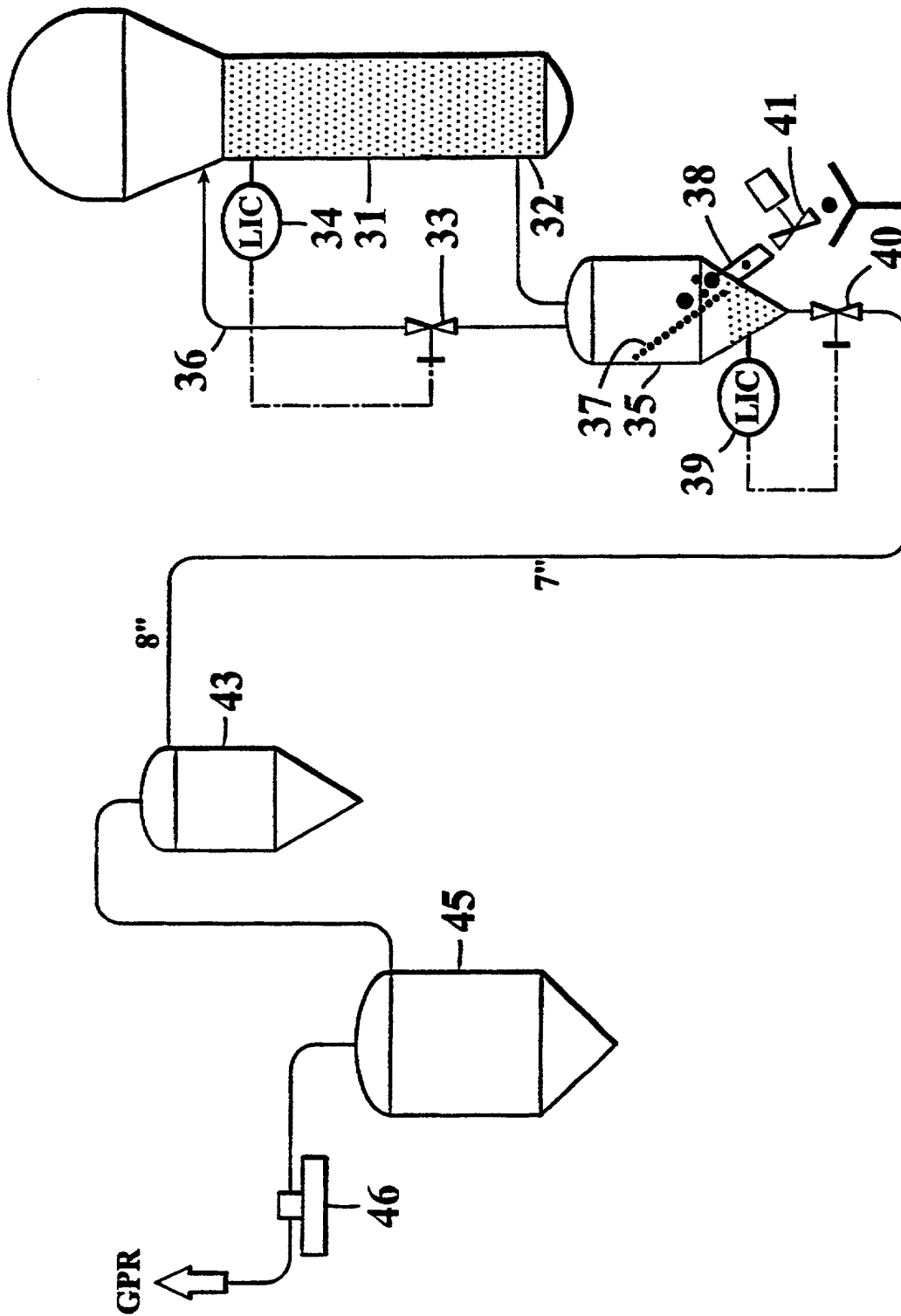


FIG. 2

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FOR PATENT AND DESIGN APPLICATIONS

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and apparatus for discharging polymerization reactors

- Insert Title:

- Fill in Appropriate
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For Use Without
Specification
Attached:

the specification of which is attached hereto. If not attached hereto,

the specification was filed on _____ as
United States Application Number _____; and /or

the specification was filed on November 12, 1999 as PCT
International Application Number PCT/FI99/00941; and was
amended under PCT Article 19 on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 (a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Insert Priority
Information:
(if appropriate)

Prior Foreign Application(s)

982456 (Number)	Finland (Country)	November 12, 1998 (Month/Day/Year Filed)
(Number)	(Country)	(Month/Day/Year Filed)
(Number)	(Country)	(Month/Day/Year Filed)
(Number)	(Country)	(Month/Day/Year Filed)
(Number)	(Country)	(Month/Day/Year Filed)

Priority Claimed

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(Filing Date)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More Than 12 Months (6 Months for Designs) Prior To The Filing Date of This Application:

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(if appropriate)

Country	Application No.	Date of Filing (Month/Day/Year)
_____	_____	_____
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I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Insert Prior U.S.
Application(s):
(if any)

(Application Number)

(Filing Date)

(Status - patented, pending, abandoned)

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(Status - patented, pending, abandoned)

I hereby appoint the following attorneys to prosecute this application and/or an international application based on this application and to transact all business in the Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the attorneys identified below, unless the inventor(s) or assignee provides said attorneys with a written notice to the contrary:

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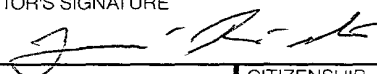
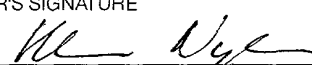
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